HYDROGEN GAS GENERATOR

【Technical Field】

The present invention relates to a self-regulating hydrogen gas generator, and more particularly to a hydrogen gas generator for actively regulating the generation of hydrogen gas due to variation in pressure of a fuel tank based on the amount of hydrogen gas generated in the fuel tank regardless of any external force.

【Background Art】

Recently, industrial development has improved quality of life, but the rapid increase of energy demand causes serious problems such as environmental pollution and exhaustion of fossil fuels.

All the countries of the world put forth great effort into the development of alternative energy sources to protect against possible exhaustion of fossil fuels, including petroleum. Particularly, the conventional use of fossil fuels causes serious environmental (air) pollution, thereby accelerating global warming and the destruction of environment. It is known that the main factors contaminating the atmosphere are nitric oxides, hydrocarbons and carbon dioxide exhausted from factories or vehicles. These exhaust gases destroy the ozone layer, thereby causing various

natural hazards, such as the direct transmission of harmful rays of the sun to the surface of the earth and the generation of climatic change, the destruction of the ecosystem, and various diseases.

In order to reduce the air pollution generated due to the use of fossil fuels, development of clean-burning fuels has been accelerated. Particularly, the development of alternative clean energy using hydrogen as an energy source is suggested. Hydrogen, which an abundant earth resource, reacts with oxygen to generate a great deal of energy and only water as a by-product, thus being the only measure for simultaneously solving the problems of the exhaustion of energy resources and environmental pollution.

However, in order to use hydrogen as an energy resource, technical problems caused by the generation of hydrogen and the safe storage and carriage of the generated hydrogen must be solved. Particularly, in case that hydrogen is used as the fuel for mobile equipment such as a hydrogen engine or hydrogen fuel cell applied to a vehicle, or a hydrogen fuel cell applied to small-sized IT (Information Technology) electronic devices, since the amount of fuel stored in the equipment is restricted, a technique of minimizing the volume and weight of a fuel tank for maintaining a high energy density is essentially required.

Particularly, in case that hydrogen is used as fuel of the hydrogen fuel cell for vehicles and IT electronic devices, the performances of the vehicles and IT electronic devices are influenced by the storage method of

the fuel and the capacity of the fuel tank. Thus, the generation and storage methods of hydrogen are considered as leading techniques. A liquid hydrogen storage method, a gaseous hydrogen storage method and a solid hydrogen storage method are used as the hydrogen storage methods, which are suggested now.

The liquid hydrogen storage method is advantageous in that hydrogen is liquefied by maintaining cryotemperatures to greatly increase the stored density of hydrogen. However, natural loss of the liquefied hydrogen must be reduced and energy loss due to the cryogenic cooling must be considered.

In the gaseous hydrogen storage method, high pressure is applied to hydrogen and the compressed hydrogen is then stored. In order to obtain an energy density suitable for mobile equipment, several hundreds of atmospheres must be applied to the hydrogen, thus increasing energy consumption and requiring a safe storage method for the super high-pressure hydrogen.

The solid hydrogen storage method is advantageous in that it is usable at room-temperature and low-pressure and is excellent in terms of safety and reduces energy loss, but is disadvantageous in that it has a low energy density per unit weight due to the high density of a hydrogen storing material. For example, a hydrogen fuel cell vehicles, which command public attention recently, use hydrogen instead of gasoline or light gas oil as fuel. In order to use hydrogen as the fuel of the hydrogen fuel cell vehicle, a large

amount of hydrogen must be stored in a storage container. In case that the conventional solid hydrogen storage method is applied to the above hydrogen fuel cell vehicle, the hydrogen fuel cell vehicle has a travel range half of that of a vehicle using gasoline as its fuel source, thus causing a difficulty in commercially using the conventional solid hydrogen storage method. In accordance with one solid hydrogen storage method for solving of the above problem, a catalyst contacts a fuel solution obtained by dissolving a hydrogen storing material, thus generating hydrogen. Since it is possible to store hydrogen in a liquid state at approximately atmospheric pressure, this method has high stability and high hydrogen storing capacity, thus being capable of being applied to mobile equipment.

The above method generates hydrogen by means of the reaction between the fuel solution and the catalyst. Accordingly, in order to start or stop the generation of hydrogen, the method requires a process for bringing the catalyst into contact with the fuel solution or separating the catalyst from the fuel solution by supplying the fuel solution to the catalyst or preventing the supply of the fuel solution using a pump, or by moving the catalyst to the fuel solution or separating the catalyst from the fuel solution using a motor. Particularly, in case that the above method is used in mobile equipment provided with a hydrogen fuel cell, when an amount of hydrogen exceeding the requirements of the mobile equipment is generated, hydrogen is accumulated in the hydrogen fuel cell and increases the pressure in the system. In this case, in order to maintain the pressure in the system below

a designated value, apparatuses, for exhausting the accumulated hydrogen, measuring the pressure and the supplied amount of hydrogen using a sensor, regulating the reacting amount of the catalyst by separating the catalyst from the fuel solution using external mechanical energy, and/or variably regulating the supplied amount of the fuel solution containing the hydrogen storing material, are additionally installed in the system, thereby complicating the structure of the system and increasing the volume of the system. Thus, the use of the system is restricted.

In order to solve the above-described problems and since an embodiment for increasing a contact area between a fuel solution and a catalyst attached to a catalyst-fixing portion is insufficient, the development of various embodiments is required. Further, technical solution and means, for preventing moisture contained in hydrogen gas in a foam state from closing fine air holes of a gas-liquid separating film, when the hydrogen gas containing fine moisture particles generated in the fuel tank collides with the gas-liquid separating film, are required. Further, technical means, for preventing moisture contained in hydrogen gas in the foam state from closing fine air holes of the gas-liquid separating film, in case that hydrogen gas flowing out of the fuel solution, which contains fine moisture particles, collides with the gas-liquid separating film, and improving performance of an apparatus, is required.

【Disclosure of the Invention】

Therefore, the present invention has been made in view of the above problems, and it is an object of the present invention to provide a self-regulating hydrogen gas generator, which is actively self-operated at an initial stage without an external energy source, and generates and supplies hydrogen gas serving as an energy source, thereby allowing the hydrogen gas to be used as clean alternative energy, preventing environmental pollution and increasing the utility of the hydrogen gas.

It is another object of the present invention to provide a self-regulating hydrogen gas generator, which has a simple structure and a minimal volume, thereby commercially applying hydrogen gas to apparatuses, systems and mobile equipment using hydrogen as fuel.

It is yet another object of the present invention to provide a self-regulating hydrogen gas generator, in which a catalyst-fixing member, provided with a catalyst attached thereto, contacting a fuel solution to generate hydrogen gas has various shapes for generating a large amount of hydrogen gas, and a fixed fuel tank, mobile and portable equipment has a structure such that hydrogen gas generated in the fuel tank is efficiently exhausted and passes through a gas-liquid separating film, thus having an improved performance.

In accordance with the present invention, the above and other objects can be accomplished by the provision of a self-regulating hydrogen gas generator, for a hydrogen fuel cell, comprising: a fuel tank, defining an

inner space having a designated volume, provided with a hydrogen outlet communicating the inner space; a fuel solution, containing a hydrogen storing material, stored in the fuel tank; and a catalyst contacting the fuel solution for generating hydrogen gas, wherein the catalyst fills a catalytic reactor, provided with a closed portion for interrupting the contact between the catalyst and the fuel solution to stop the generation of hydrogen gas in case that a pressure of the fuel tank increases due to the generation of hydrogen gas by the contact between the catalyst and the fuel solution, and an opened portion contacting the fuel solution for generating hydrogen gas in case that the pressure of the fuel tank decreases due to the use of the generated hydrogen gas by the fuel cell, so that the generation and interruption of hydrogen gas are actively regulated based on the increase and decrease of the pressure of the fuel tank.

Preferably, the catalytic reactor may include elastic means having a designated compressing and restoring force for moving the catalyst toward the closed or opened portion, based on the increase and decrease of the pressure of the fuel tank due to the generation of hydrogen gas, to regulate the generation of hydrogen gas, and the catalyst may be combined with a catalyst-fixing member, which is movable in the catalytic reactor.

Further, preferably, the fuel tank may include gas-liquid separating means for separating the generated hydrogen gas from the fuel solution in a liquid state and exhausting the separated hydrogen gas to the outside. More preferably, the gas-liquid separating means may be a gas-liquid

separating film having various shapes fixedly installed in the fuel tank so that a designated space between the inner hole of the outlet and the fuel solution is defined to easily exhaust the hydrogen gas through the outlet.

Preferably, the gas-liquid separating means may include a collector floating on the fuel solution filling a designated level of the fuel tank, a collection hole protruded from the collector and exposed to the upper surface of the fuel solution for introducing the hydrogen gas generated in the fuel tank to the collector therethrough, and a drain hose connecting the other side of the collector, opposite to the collection hole, and the outlet, for exhausting the hydrogen gas collected by the collector. Further, preferably, the fuel tank may include hydrogen gas retaining means for converting hydrogen gas in a fine foam state, generated by the contact of the fuel solution and the catalyst, into large-sized hydrogen gas bubbles and allowing the obtained large-sized gas bubbles to pass through the gas-liquid separating means. Moreover, preferably, at least one collision member for preventing hydrogen gas in a fine foam state, generated in the fuel tank, containing moisture, from directly contacting the gas-liquid separating film, may be interposed between the fuel solution and the gas-liquid separating film.

【Brief Description of the Drawings】

The above and other objects, features and other advantages of the

present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a partially exploded perspective view of a hydrogen gas generator in accordance with a first embodiment of the present invention;

Figs. 2 and 3 are partially exploded perspective views illustrating the operation of a catalytic reactor applied to the hydrogen gas generator in accordance with the first embodiment of the present invention;

Fig. 4 is an exploded perspective view of the catalytic reactor of Figs. 2 and 3;

Figs. 5 and 6 are partially exploded perspective views of another catalytic reactor having a shape differing from that of the catalytic reactor of Figs. 2 and 3;

Figs. 7 to 13 illustrate various embodiments of a catalyst-fixing member, to which a catalyst is connected;

Figs. 14 to 18 illustrate various embodiments of gas-liquid separating means provided in a fuel tank;

Figs. 19 and 20 illustrate hydrogen gas retaining means formed on the external surface of the catalytic reactor filled with a fuel solution;

Figs. 21 and 22 illustrate a collision member interposed between the fuel solution of the fuel tank and a gas-liquid separating film;

Figs. 23 to 28 are each schematic views of hydrogen gas generators in accordance with second, third and fourth embodiments of the present invention; and

Fig. 29 is a schematic view of the hydrogen gas generator of the present invention used as a fuel feed system of a portable telephone.

【Best Mode for Carrying Out the Invention】

Now, preferred embodiments of the present invention will be described in detail with reference to the annexed drawings. Hereinafter, the description of conventional peripheral devices of a hydrogen gas generator will be omitted.

A hydrogen gas generator (H) of the present invention is characterized in that the generation of hydrogen gas and the interception of the hydrogen gas are repeatedly performed without using external energy.

More specifically, the hydrogen gas generator (H) of the present invention comprises a fuel tank 10 having a designated size for maintaining a hermetically sealed space, a hydrogen storing material fuel solution 17 contained in the fuel tank 10, and a catalyst 21 contacting the hydrogen storing material fuel solution 17 for generating hydrogen gas. The catalyst 21 fills a catalyst reactor 20 having a designated shape. Fig. 1 is a perspective view of the hydrogen gas generator, in which the fuel tank 10 is partially exploded in accordance with a first embodiment of the present invention.

As shown in Fig. 1, the fuel tank 10 has the designated size for containing the fuel solution having a certain volume, and the size and shape

of the fuel tank 10 vary according to the purpose and kind of the fuel tank 10. An outlet 12 for discharging hydrogen generated in the fuel tank 10 is formed in one side surface of the fuel tank 10, and a valve, such as a quick connector 15, is installed on the outlet 12 and is combined with a hydrogen fuel cell.

The fuel tank is filled with the hydrogen storing material fuel solution 17 having a certain volume, when the fuel tank 10 is initially manufactured, and is then hermetically sealed so that the fuel tank cannot be recharged and discharged. Alternately, a hole 14 is formed through one side of the fuel tank 10 so that the fuel solution 17, after use, is discharged from the fuel tank 10 through the hole 14 and new fuel solution 17 fills the fuel tank 10 through the hole 14, and a vent hole 13 serving as a safety measure is formed through one side of the fuel tank 10 so that hydrogen is discharged from the inside of the fuel tank 10 to the outside.

The hydrogen storing material fuel solution 17 applied to the embodiment of the present invention contains $NaBH_4$ 20%, KOH 8% and H_2O 72%. The catalyst 21 is made of a material, which efficiently generates hydrogen by contact with the fuel solution 17. In the present invention, the catalyst 21 is made of Raney Ni.

Figs. 2 and 3 are partially exploded perspective views illustrating the operation of the catalytic reactor 20 applied to the hydrogen gas generator (H) in accordance with the first embodiment of the present invention. Fig. 4 is an exploded perspective view of the catalytic reactor 20

of Figs. 2 and 3.

The catalytic reactor 20 of the hydrogen gas generator (H) of the present invention has a structure such that the contact or isolation between the catalyst 21 and the fuel solution 17 of the fuel tank 10 is automatically controlled by the pressure of hydrogen generated in the fuel tank 10. In this embodiment of the present invention, the catalytic reactor 20 is positioned at the inside of the fuel tank 10 such that hydrogen is generated due to the contact between the fuel solution 17 and the catalyst 21 under the condition that the catalytic reactor 20 is dipped in the fuel solution 10. In other embodiments of the present invention, the catalytic reactor 20 is positioned at the outside of the fuel tank 1, and will be described in brief later.

That is, as shown in Figs. 2 and 3 and Fig. 4, it is preferable that the catalytic reactor 20 is a tube including a main body 29 provided with an opened portion 28 positioned at one end thereof and communicated with the outside and a closed portion 27 positioned at the other end thereof. The opened portion 28 is obtained by opening one end of the main body 29 or forming a cutting portion at the side surface of one end of the main body 29, and has a structure such that the catalyst 21 is exposed to the outside through the opened portion 28 and contacts the fuel solution 17.

Further, elastic means 24 having an excellent restoring force is positioned at the inside of the closed portion 27 formed at the end of the main body 29, and the catalyst 21 is attached to a catalyst-fixing member

22 reciprocating in the closed portion 27. In case that the pressure in the fuel tank 10 increases, the catalyst-fixing member 22 moves toward the closed portion 27 so as to prevent the catalyst 21 from contacting the fuel solution 17, and in case that the pressure in the fuel tank 10 decreases, the catalyst-fixing member 22 moved toward the closed portion 27 is returned to an initial position toward the opened portion 28 by the elastic means 24 so as to cause the catalyst 21 to contact the fuel solution 17 through the opened portion 28 to generate hydrogen.

The catalyst 21 is a powder or lump type. In case that the catalyst 21 is a powder type, the powdery catalyst 21 is introduced into a net made of various materials, which does not pass powder but passes the fuel solution 17 and the hydrogen gas, or is attached to the net or a substrate using an adhesive agent, and is then attached to the catalyst-fixing member 22. Alternately, in this case, the powdery catalyst 21 is processed to have a designated shape suitably for the structure of the catalyst-fixing member 22, is sintered, and is then attached to the catalyst-fixing member 22.

More specifically, Raney Ni used as the catalyst 21 of the embodiment of the present invention has a large surface area, thus being stored in distilled water, and is characterized in that Raney Ni spontaneously combusts when exposed to air. Accordingly, in order to use Raney Ni as the catalyst 21, only the surface of Raney Ni is oxidized so that Raney Ni is stably used in the atmosphere. This method reduces the hydrogen generating capacity of the catalyst 21. Thus, in embodiments of

the present invention, the catalyst 21 is manufactured by two methods, in which the surface of Raney Ni is not oxidized. In the first method, Raney Ni is attached to a magnet, and is then used. That is, the magnet is attached to the catalyst-fixing member 22 (with reference to Fig. 12), and then Raney Ni is attached to the magnet attached to the catalyst-fixing member 22.

In the second method, Raney Ni is attached to a net or substrate made of various materials in an aqueous solution such as distilled water. Since Raney Ni is stored in distilled water, when Raney Ni stored in the distilled water is manufactured into the catalyst 21, it is possible to prevent the reduction of the hydrogen generating capacity of the catalyst 21 due to the surface oxidation. In the embodiment of the present invention, the catalyst 21 is manufactured by fixing Raney Ni to a nickel mesh using urethane foam.

As the higher the temperature is, the greater the hydrogen generating capacity of the catalyst 21, including Raney Ni, is. In case that a worker wants to generate a large amount of hydrogen using a small amount of the catalyst 21, a heating medium, such as a hot wire, for heating the catalyst 21 or the fuel by itself or by an external power supply source is installed in at least one of the fuel tank 10, the catalytic reactor 20 and the catalyst-fixing member 22. The above method using the heating medium increases the solubility of the hydrogen storing material and its by-product, thus causing the hydrogen storing material and the by-product to store a

large amount of hydrogen.

The catalyst-fixing member 22 has a structure or shape for allowing the catalyst 21 to be easily attached thereto and effectively preventing the fuel solution 17 from being introduced thereinto when the catalyst 21 enters into and leaves the inside of the main body 29. The catalyst-fixing member 22 of the embodiment of the present invention includes both wings 23 and 23', and a catalyst fixing section 23c, having various shapes for receiving the catalyst 21, interposed between the wings 23 and 23'.

When the catalyst-fixing member 22 moves toward the inside and outside of the closed portion 27 of the main body 29, in order to prevent the fuel solution 17 in a liquid state from being introduced into the closed portion along the outer surface of the catalyst-fixing member 22, fuel solution interception members 23a and 23b are respectively and simultaneously formed between both ends of the catalyst-fixing member 22 and the inner surface of the main body 29 or between the catalyst-fixing member 22 and the elastic means 24. An installation groove 25a is formed on the inner circumference of the main body 29, and a subsidiary interception member 25 having a ring shape is inserted into the installation groove 25a so as to prevent the fuel solution from being introduced into the main body 29 along the external circumference of the catalyst-fixing member 22 when the catalyst-fixing member 22 provided with the catalyst 21 attached thereto moves. Fig. 4 illustrates the above components of the catalytic reactor 20.

Figs. 5 and 6 are partially exploded perspective views of another catalytic reactor 20 having a shape differing from that of the above catalytic reactor 20. Here, the opened portion 28 is formed at one end of the main body 29, the catalyst 21 is attached to the catalyst fixing section 23c such that the catalyst 21 surrounds the overall external circumference of the catalyst fixing section 23c to enlarge the contact area between the catalyst 21 and the fuel solution, thereby increasing the amount of the generated hydrogen. Other elements of the catalytic reactor 20 are the same as those of the above-described catalytic reactor.

Preferably, the elastic means 24 applied to this embodiment of the present invention is made of compressed gas and elastomer for restoring the catalyst-fixing member 22 to an initial position when the catalyst-fixing member 22 is forcibly introduced into the inside of the closed portion 27 and hydrogen filling the fuel tank 10 is exhausted through the outlet 12 using a hydrogen fuel cell so that the pressure in the fuel tank 10 decreases in case that the exposed state of the catalyst 21 positioned on the catalyst-fixing member 22 is maintained at the atmospheric pressure and the pressure in the fuel tank 10 increases to higher than the atmospheric pressure and the increased pressure is applied to one side surface of the catalyst-fixing member 22 exposed to the opened portion 28 of the catalytic reactor 20. In this embodiment of the present invention, the elastic means 24 is made of a compressed coil spring.

Figs. 7 to 13 illustrate various embodiments of the catalyst-fixing

member 22. The various embodiments of the catalyst-fixing member 22 serve to improve the structure of the catalyst-fixing section 23c, to which the catalyst 21 is attached, so as to maximally increase the contact area between the catalyst 21 and the fuel solution 17.

That is, the catalyst-fixing member 22 applied to the embodiment of the present invention includes the wings 23 and 23' sliding on the inner surface of the main body 29 and the catalyst-fixing section 23c, having various shapes for receiving the catalyst 21, interposed between the wings 23 and 23'. Particularly, the catalyst-fixing section 23c has a multi-layered structure comprising a plurality of stacked plates, or various structures such as fan, conical, circular structures, etc., so that a large amount of the catalyst 21 is attached to the surface of the catalyst-fixing section 23c. A magnet 23d may be attached to one side surface or both side surfaces of the catalyst-fixing section 23c so that the metallic catalyst 21 can be attached to the catalyst-fixing section 23c without any separate process (with reference to Fig. 12).

Hereinafter, a process for generating hydrogen by the hydrogen gas generator (H) of the present invention will be described in detail. The fuel solution 17 in an amount of 10mℓ is introduced into the fuel tank 10, and the catalyst 17 in an amount of 0.1g made of Raney Ni is introduced into the fuel tank 10. Then, the fuel tank 10 generates hydrogen gas at the rate, corresponding to 12SCCM (Standard Cubic Centimeter per Minute) at room temperature or 1W of the fuel cell, for approximately 10 hours. The

hydrogen gas generated in the fuel tank 10 is supplied to an external system, such as a hydrogen engine, using hydrogen as a fuel, or a hydrogen fuel cell, through the outlet 12 of the fuel tank 10. In case that the amount of the hydrogen gas required by the external system is less than 12SCCM, or the hydrogen gas is not exhausted by cutting off the power, the generated hydrogen gas is accumulated in the fuel tank 10 and the pressure in the fuel tank 10 increases to 1.5 atmospheres (P1).

There is generated a difference of pressures between the fuel tank 10 and the main body 29 of the catalytic reactor 20, and the increased pressure in the fuel tank 10 presses one end of the opened portion 28 of the main body 29 of the catalytic reactor 20. When the catalyst-fixing member 22 moves toward the closed portion 27 of the main body 29 of the catalytic reactor 20, the catalyst 21 exposed to the fuel solution 17 made of the hydrogen storing material gradually enters into the main body 29 so that the contact area between the catalyst 21 and the fuel solution 17 is reduced, thereby reducing the generation of hydrogen gas and then stopping the generation of hydrogen gas.

When the external system again uses hydrogen gas, the generated hydrogen gas is exhausted from the fuel tank 10. Then, the pressure in the fuel tank 10 is reduced, the difference of pressures between the fuel tank 10 and the main body 29 of the catalytic reactor 20 decreases, and the elastic means 24 positioned in the main body 29 is returned to the initial position so that the catalyst-fixing member 22 moves toward the opened

portion 28 and the catalyst 21 again contacts the fuel solution 17. Thereby, the hydrogen gas generator (H) of the present invention intermittently generates hydrogen gas.

Figs. 14 to 18 illustrate various embodiments of gas-liquid separating means 40 provided in the fuel tank 10.

The gas-liquid separating means 40 serves to prevent the hydrogen in a gas state generated in the fuel tank 10 filled with the water-soluble fuel solution 17 from being exhausted together with the exhaustion of the fuel solution in a liquid state, and is more usable in a mobile or portable fuel cell rather than a fixed fuel cell.

That is, each of the gas-liquid separating means 40 shown in Figs. 14 to 16 includes a gas-liquid separating film 42. The gas-liquid separating film 42 is made of hydrophobic silicon rubber, which is more permeable to hydrogen gas than water, a porous non-metal such as Teflon, or metal having selective permeability to hydrogen. In Fig. 14, the gas-liquid separating film 42 installed in the fuel tank 10 is separated from the inner hole of the outlet 12 by a designated interval. An implant member 43 provided with air holes or hydrogen paths, for preventing the movement of the gas-liquid separating film 42 and efficiently exhausting hydrogen when the pressure in the fuel tank 10 increases due to the generation of the hydrogen gas or the fuel tank 10 moves, is interposed between the inner surface of the fuel tank 10, where the outlet 12 is positioned, and the gas-liquid separating film 42. The gas-liquid separating film 42 may have other

structures without the implant member 43 so that the gas-liquid separating film 42 is fixed to the inner surface of the fuel tank 10 and the generated hydrogen gas is efficiently exhausted.

In Fig. 15, the hermetically sealed type gas-liquid separating film 42, which is positioned in the fuel tank 10, has the same shape as that of the fuel tank 10 and a size slightly smaller than that of the fuel tank 10, and is separated from the inner wall of the fuel tank 10. Also, the implant member 43, for preventing the contact of the inner wall of the fuel tank 10 and the gas-liquid separating film 42 due to the increased pressure or movement of the fuel tank 10 and allowing the hydrogen gas to smoothly move, is interposed between the inner wall of the fuel tank 10 and the gas-liquid separating film 42. In Fig. 16, the gas-liquid separating film 42 is U-shaped, and is positioned in the fuel tank 10 such that the central area of the gas-liquid separating film 42 is disposed under the inner hole of the outlet 12.

In Figs. 17 and 18, the gas-liquid separating means 40 includes a collector 44, made of a material floating on the fuel solution 17 in the liquid state, for collecting generated gas and then exhausting the gas to the outside. A collection hole 46 for introducing the hydrogen gas from the fuel tank 10 thereinto is protruded from one side of the collector 40, and a drain hose 48 for exhausting the hydrogen gas collected by the collector 44 to the outlet 12 connects the other side of the collector 40 opposite to the collection hole 46 and the outlet 12.

The above-described various structures of gas-liquid separating means 40 may be properly selected based on characteristics of equipment using hydrogen fuel, and the collector 44 may be made of any material having specific gravity lower than that of water.

Figs. 19 and 20 illustrate hydrogen gas retaining means 50 for temporarily collecting the hydrogen gas generated in the catalytic reactor 20 filled with the fuel solution 17 in the fuel tank 10 and for converting small-sized hydrogen bubbles in a fine foam state into large-sized hydrogen bubbles. The hydrogen gas retaining means 50 has various structures for indirectly cutting off the circumference of the catalytic reactor 20, thus allowing the hydrogen bubbles in the fine foam state to be temporarily aggregated and then exhausted to the outside.

When the fuel solution 17 filling the fuel tank 10 contacts the catalyst 21 of the catalytic reactor 20 to exhaust the fine hydrogen foam, the hydrogen gas retaining means 50 serves to collect the fine hydrogen foam and convert the foam into large-sized hydrogen bubbles and then to allow the large-sized hydrogen bubbles to pass through the gas-liquid separating film 42. In case that the small-sized hydrogen bubbles in the fine foam state directly reach the gas-liquid separating film 42, the small-sized hydrogen bubbles in the fine foam state close fine air holes of the gas-liquid, thus causing a difficulty of efficiently exhausting the hydrogen gas. Accordingly, the hydrogen gas retaining means 50 prevents the above problem.

Particularly, the hydrogen gas generator (H) of the present invention can be applied to fixed, mobile or portable articles using a hydrogen fuel cell. Even though the fuel tank 10 is disposed at any position of the article, the hydrogen gas generated in the fuel tank 10 must be efficiently exhausted. Thus, the gas-liquid separating film 42 can be installed at any portion, i.e., left, right, upper and lower portions, of the inside of the fuel tank 10. In the embodiments of the present invention shown in Figs. 19 and 20, the gas-liquid separating means 42 are respectively installed at the upper and lower portions of the inside of the fuel tank 10, and a connection pipe 54 connects both spaces obtained by the upper and lower gas-liquid separating means 42. Although the fuel tank 10 stands at any position, spaces cut off from the fuel solution by the gas-liquid separating films 42 are connected to each other through the connection pipe 54 so that the hydrogen gas bubbles generated in the fuel tank 10 communicate between the spaces, thereby efficiently exhausting the hydrogen gas bubbles to the outside through the outlet 12. The hydrogen gas retaining means 50 is formed integrally with the fuel tank 10, or the catalytic reactor 20 is formed integrally with the hydrogen gas retaining means 50.

Figs. 21 and 22 respectively illustrate embodiments, in which a collision member 52 is interposed between the fuel solution 17 of the fuel tank 10 and the gas-liquid separating film 42. That is, the collision member 52 serves to prevent the fine hydrogen foam, generated in the fuel tank 10, containing moisture, from directly contacting the gas-liquid separating film

42. When the hydrogen gas rises and collides with the collision member 52, the moisture contained by the hydrogen gas due to the fuel solution 17 is separated from the hydrogen gas. Thereby, only the obtained pure hydrogen gas passes through the gas-liquid separating film 42. In the same manner as the above-described hydrogen gas retaining means 50, the collision member 52 may have various structures based on installation types of the fuel tank 10 or applied articles.

Figs. 23 to 28 are each schematic views of hydrogen gas generators in accordance with second, third and fourth embodiments of the present invention. In these embodiments of the present invention, the hydrogen gas generator is a fuel tank external installation type, in which the catalytic reactor 20 is detachably attached to the outer surface of the fuel tank 10.

That is, the catalytic reactor 20 provided with the elastic means 24 and the catalyst-fixing member 22 positioned therein is inserted into an installation groove 60 formed in one outer surface of the fuel tank 10.

More specifically, in the second embodiment shown in Figs. 23 and 24, a stopper 60a is protruded from one end of the catalytic reactor 20, and a stopper-fixture 60b for fixing the stopper 60a is formed in the front end of the inside of the installation groove 60. A through hole 62 communicating with the inside of the fuel tank 10 is formed at a designated position of the inner circumference of the installation groove 60, the elastic means 24 is positioned on the bottom of the installation groove 60 inside the through

hole 62, a through hole sealing member 26 for sealing the through hole 62 is combined with the elastic means 24, a hydrogen generation regulating hole 64 communicating with the inside of the fuel tank 10 for introducing a fluid of the fuel tank 10 is formed through the bottom of the installation groove 60, and the gas-liquid separating film 42 is installed in front of the hydrogen generation regulating hole 64 in the fuel tank 10.

As shown in Fig. 23, before the catalytic reactor 20 is inserted into the installation groove 60 of the fuel tank 10, the through hole sealing member 26 positioned in the installation groove 60 seals the through hole 62. Then, as shown in Fig. 24, when the catalytic reactor 20 is inserted into the installation groove 60 of the fuel tank 10, the through hole sealing member 26 presses the elastic means 24 so that the through hole 62 is exposed to the outer circumference of the catalytic reactor 20, and when the catalytic reactor 20 is fully inserted into the installation groove 60 of the fuel tank 10, the through hole 62 contacts the catalyst 21 provided on the catalytic reactor 20, thereby allowing hydrogen gas to be generated.

When the inner pressure of the fuel tank 10 rises due to the generation of hydrogen gas and exceeds a designated level (in case that the hydrogen gas is not used), a part of the hydrogen gas accumulated in the fuel tank 10 is introduced into the installation groove 60 through the hydrogen generation regulating hole 64 formed through the bottom of the installation groove 60, and the inner pressure of the installation groove 60 rises. Then, the through hole sealing member 26 pushes the catalyst-

fixing member 22 of the catalytic reactor 20, and releases its force from the elastic means 24. As the elastic means 24 is stretched, the contact area between the catalyst 21 and the fuel solution 17 gradually decreases and the through hole 62 is fully sealed by the through hole sealing member 26, thereby stopping the generation of hydrogen gas. When the external system uses the generated hydrogen gas, the pressure of hydrogen in the fuel tank 10 is decreased and the fluid in the installation groove 60 is directed into the fuel tank 10. Then, the elastic means 24 positioned on the catalytic reactor 20 is constricted and the catalyst-fixing member 22 pushes the through hole sealing member 26 so that the catalyst 21 contacts the fuel solution 17. By automatically achieving the generation of the hydrogen gas and the interruption of the hydrogen gas by means of repeating the above-described operation, the hydrogen gas generator (H) of the present invention generates and supplies hydrogen gas required by a hydrogen fuel cell, etc. The hydrogen generation regulating hole 64 can be disposed at any position, which allows the fluid of the fuel tank 10 to be introduced into the installation groove due to the increased inner pressure of the fuel tank 10 to push the through hole sealing member 26 or the catalyst-fixing member 22 of the catalytic reactor 20.

In the third embodiment shown in Figs. 25 and 26, a catalyst exposure regulating portion 66 having a sealed space is extended from the end of the above-described catalytic reactor 20, i.e., the outer surface of the catalyst-fixing member 22. A hydrogen generation regulating hole 64',

which coincides with the hydrogen generation regulating hole 64 when the catalytic reactor 20 is inserted into the installation groove 60 and regulates the generation of hydrogen gas by moving the catalyst-fixing member 22 based on the increase and decrease of the inner pressure of the fuel tank 10, is formed through a designated position of the catalyst exposure regulating portion 66.

The hydrogen gas generator (H) of the third embodiment is the same as the hydrogen gas generator (H) of the second embodiment in that the generation of the hydrogen gas and the interruption of the hydrogen gas are achieved by the increase and decrease of the inner pressure of the fuel tank 10. However, in the third embodiment, when the inner pressure of the fuel tank 10 increases, the fluid in a high pressure state is introduced into the catalyst exposure regulating portion 66 formed at the inner front end of the catalytic reactor 20, and pushes the catalyst-fixing member 22 of the catalytic reactor 20. On the other hand, when the inner pressure of the fuel tank 10 decreases, the fluid having introduced into the catalyst exposure regulating portion 66 is exhausted, and pushes the catalyst-fixing member 22 by means of the elastic means 24 positioned in the catalytic reactor 20 so that the catalyst 21 contacts the fuel solution 17, thereby allowing hydrogen gas to be generated.

In the fourth embodiment shown in Figs. 27 and 28, elastic means is not provided in the catalytic reactor 20 combined with the installation groove 60, and the catalyst-fixing member 22 is provided only on the front

end of the main body 29 of the catalyst-fixing member 22. A stopper 61a, serving as fixing means, is popped into and out of the outer surface of the main body 29 by an elastic spring 67 positioned in an installation hole 65 formed in the central area of the main body 29, and a stopper-fixture 61b for fixing the stopper 61a to prevent the catalytic reactor 20 from being separated from the installation groove 60 after the catalytic reactor 20 is inserted into the installation groove 60.

As shown in Fig. 28, when the catalytic reactor 20 is forcibly inserted into the installation groove 60, the stopper 61a formed on the outer circumference of the catalytic reactor 20 is caught by the stopper-fixture 61b so that the catalytic reactor 20 is fixed into the installation groove 60.

As described above, the catalyst 21 of the catalytic reactor 20 combined with the fuel tank 10 contacts the fuel solution 17 filling the fuel tank 10, thus generating hydrogen gas. When the inner pressure of the fuel tank 10 increases more than a designated value, the fluid at an increased pressure of the fuel tank 10 is introduced into the installation groove 60 through the hydrogen generation regulating hole 64 formed through the bottom of the installation groove 60 and pushes the through hole sealing member 26. Then, the through hole sealing member 26 applies pressure to the catalytic reactor 20 contacting the through hole sealing member 26, and the stopper 61a formed on the outer circumference of the catalytic reactor 20 is popped into the installation hole 65 by pressing the elastic spring 67 provided in the installation hole 65, and is then

separated from the stopper-fixture 61b. Thereby, the hydrogen gas generator (H) in accordance with this embodiment of the present invention generates hydrogen gas by a user forcibly inserting the catalytic reactor 20 into the installation groove 60.

As shown in Fig. 29, the hydrogen gas generator (H) of the present invention may be used in a hydrogen fuel cell of a portable telephone (P).

As described above, the hydrogen gas generator (H) of the present invention actively self-regulates the generation and interruption of hydrogen gas based on the pressure of the generated hydrogen gas without any external force, thus having a simple structure and reducing production costs. Further, the hydrogen gas generator (H) of the present invention has reduced volume and weight, thereby greatly increasing energy density per volume and weight of a fuel cell serving as an energy source for various equipment.

After all hydrogen gas is exhausted from the fuel solution 17, in the same manner as a conventional fuel cell, the hydrogen gas generator (H) of the present invention exhausts the waste fuel solution 17 through the hole 14 formed through the fuel tank 10 and is then refilled with a new fuel solution 17. In case that the hydrogen gas generator (H) is combined with the fuel cell through the quick connector 15 positioned on the outlet 12 of the fuel tank, the quick connector 15 is opened to supply the hydrogen gas to the fuel cell, and in case that the hydrogen gas generator (H) is separated from the fuel cell, the quick connector 15 is closed to prevent the

hydrogen gas from being exhausted to the outside so that the pressure of the fuel tank 10 slightly increases and the reaction between the catalyst 21 and the fuel solution 17 is prevented, thereby stably storing the hydrogen gas below a designated pressure.

The hydrogen gas generator (H) maximally increases a contact area between the catalyst 21 and the fuel solution 17 by employing the various embodiments of the catalyst-fixing member 22, thereby generating a great amount of hydrogen gas and enlarging the usable range of the hydrogen fuel cell. Further, the hydrogen gas generator (H) comprises the hydrogen gas retaining means 50 having various structures, and the collision member 52 having various structures interposed between the fuel solution 17 and the gas-liquid separating film 42, so that the hydrogen gas generated in the fuel tank 10 is efficiently supplied to the outside, thereby improving the performance of the hydrogen fuel cell. In case that the gas-liquid separating films 42 are additionally installed in the fuel tank 10, the hydrogen gas is smoothly circulated through the connection pipe 54. Thus, various structures of the fuel tank 10 are applied to the hydrogen fuel cell based on applied products, and extend the usable range of the hydrogen fuel cell, thereby being capable of effectively using energy.

【Industrial Applicability】

As apparent from the above description, the present invention

provides a self-regulating hydrogen gas generator, which is miniaturized, reduces production cost, volume and weight thereof, thus improving energy density per unit volume and weight and being applied to mobile or portable equipment using hydrogen as fuel as well as a large-sized hydrogen fuel cell device using hydrogen as fuel. Accordingly, the self-regulating hydrogen gas generator stimulates the use of hydrogen gas as clean alternative energy, and causes the hydrogen gas to be used as a substitute for gradually exhausted fossil fuels, thereby preventing air pollution and providing a clean environment.

Although the preferred embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.